How is building energy use related with occupants behaviors and the building usage modes?

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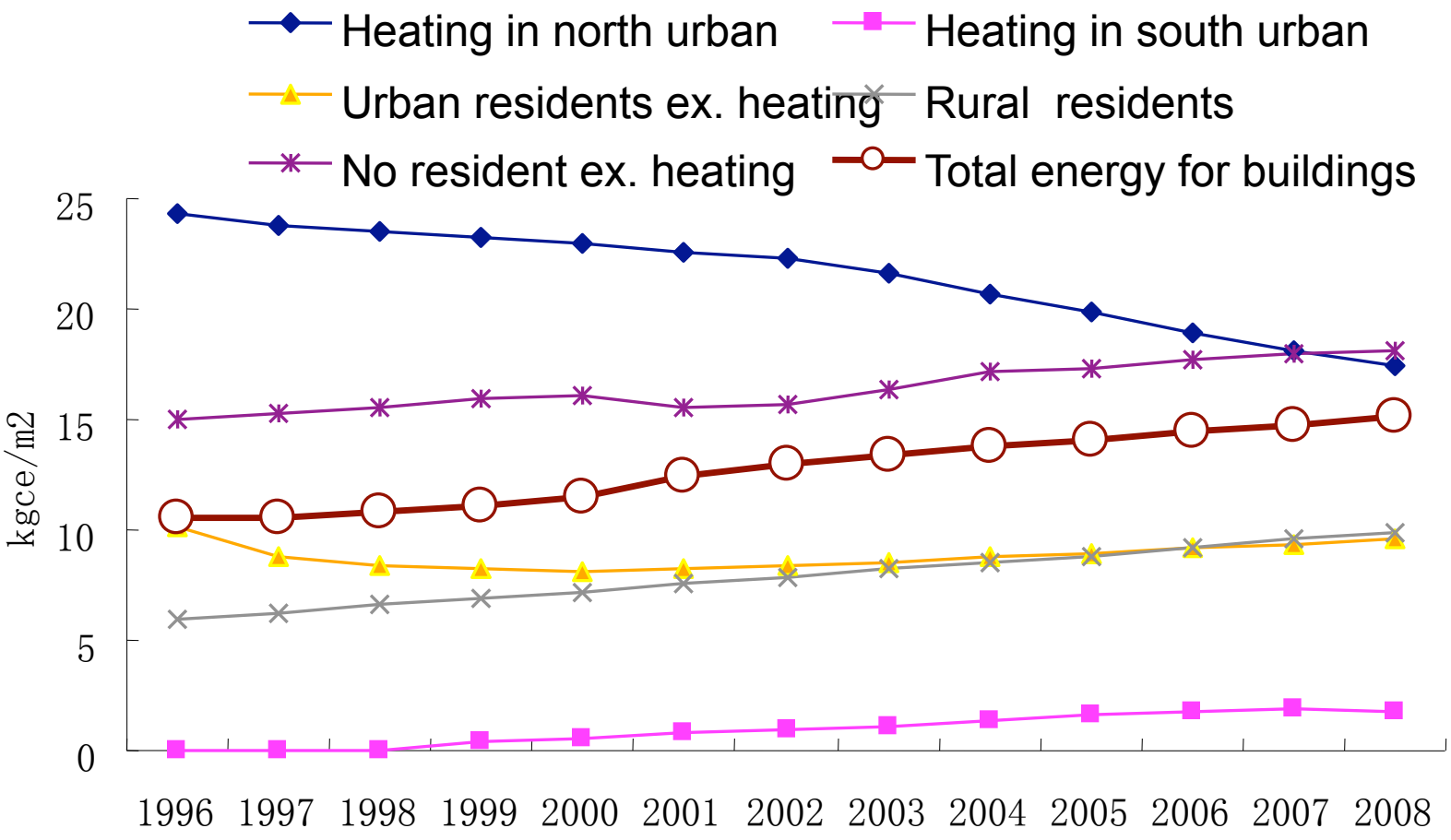
China Building Energy Use Trend
(kgce/m²)



Reasons of Reduction in Heating Energy

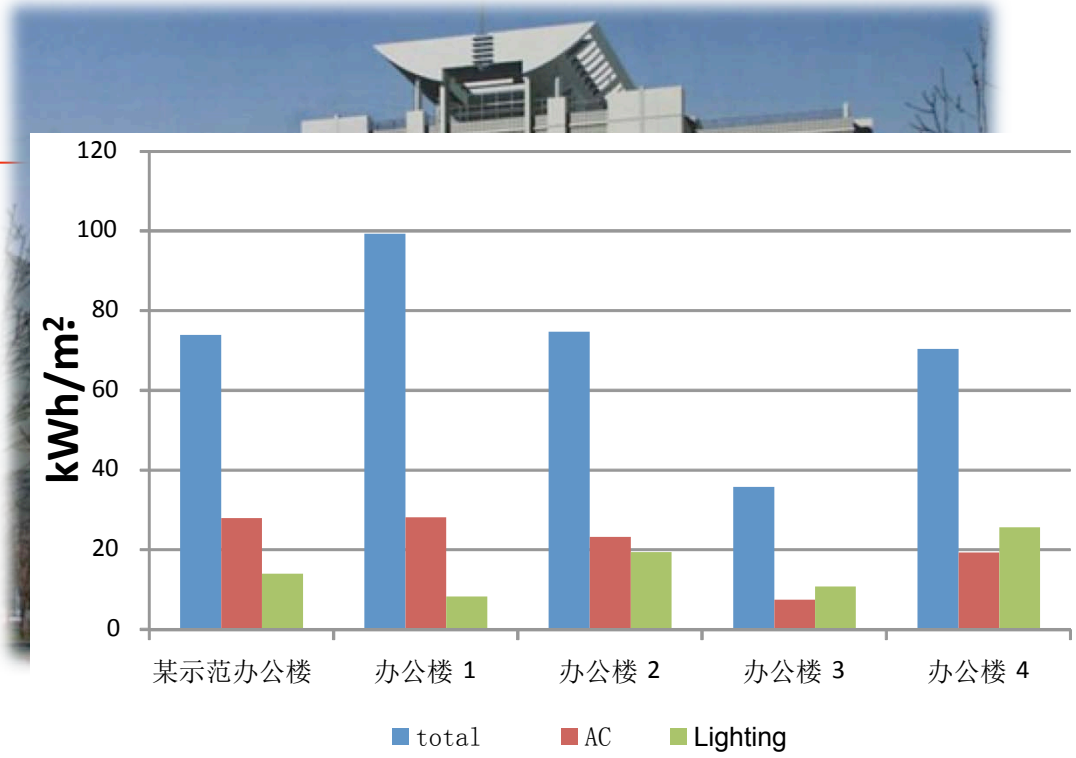
- **New code has been put into effect**
  - **More than 90% of new buildings meet the new code for energy efficiency**
  - **Some new buildings are better than the code**

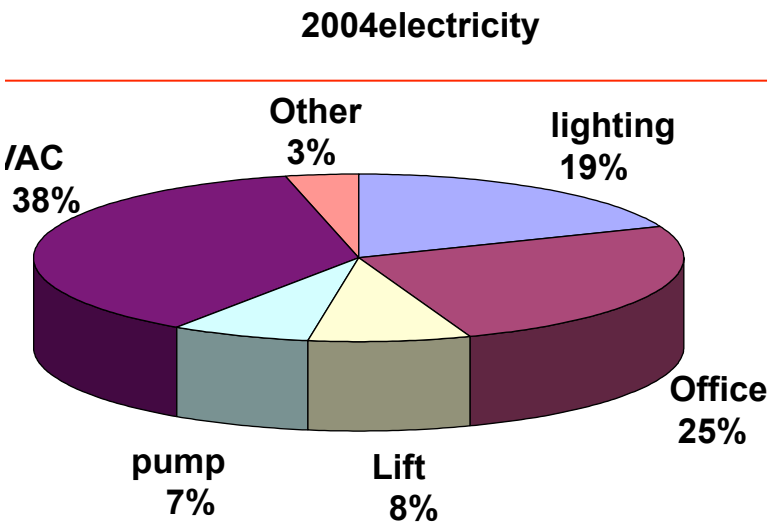
    e.g. a new building in Shenyang < 75 kWh/m^2
- **Retrofit on existing buildings**
  - **Large amount of buildings have been re-insulated during the last 5 years**
- **Improvement on heat sources**
  - **Remove small boilers，installation of heat pumps, CHP etc.**

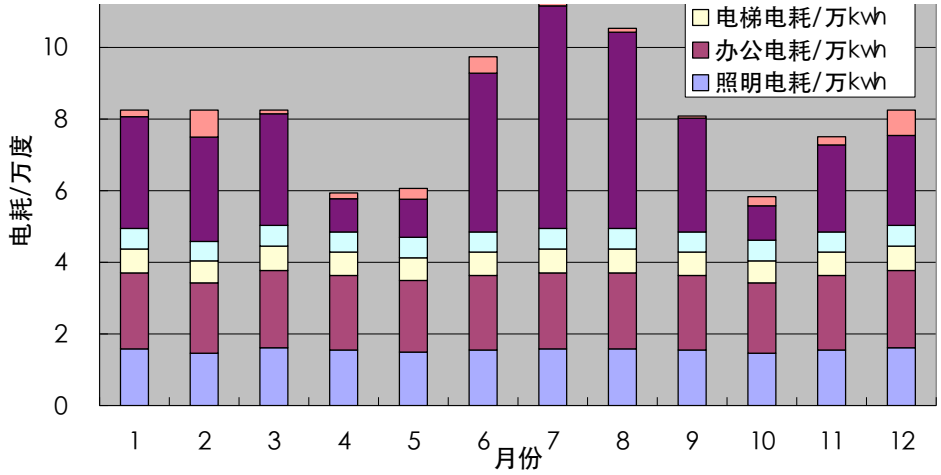
Other Usage of Building Energy（except heating in north urban）

- Increase overall
- Residential：lighting, home appliances, and AC go up with rising living standard
- Non-residential: energy audit & retrofit at one side, but large number of new glass boxes appear at the other side
- Low energy demo buildings：are they energy saving?

Sino-US 21 Century Building



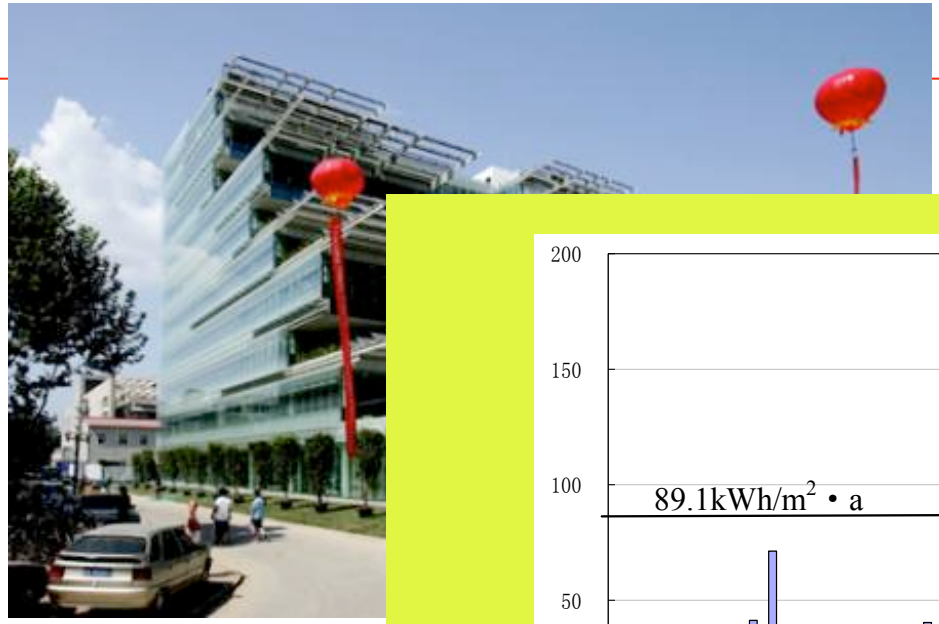


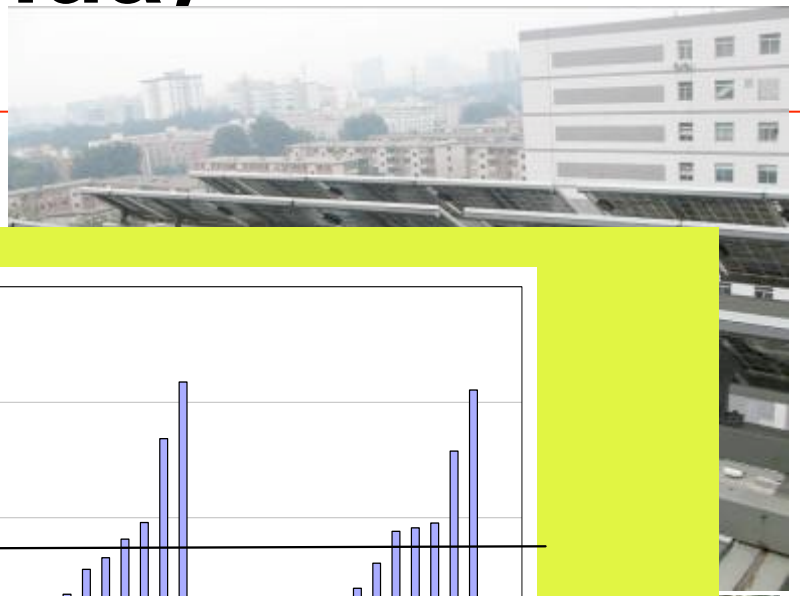


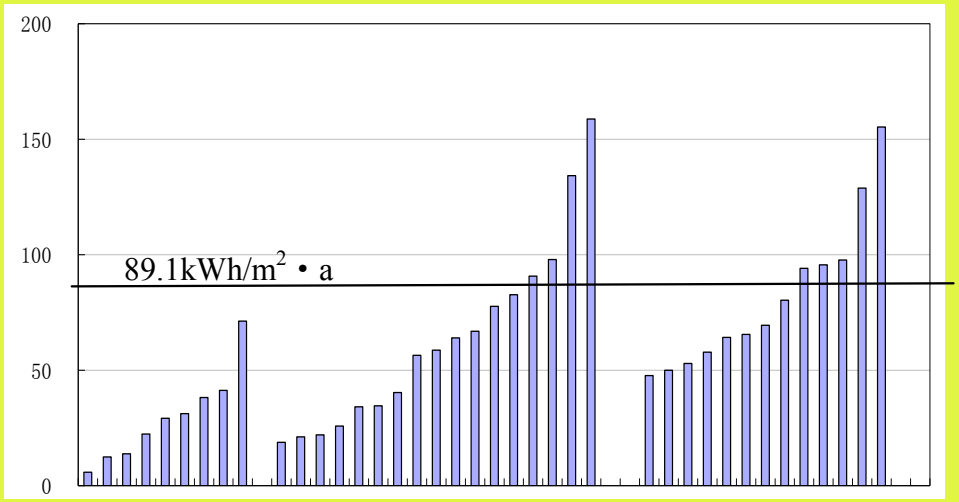
Annual energy (not including heating):

- AC: 28.0 kWh/m²
- LT: 14.0 kWh/m²
- Total: 74.0 kWh/m²

Sino-Italy Low Energy Building (Tsinghua)

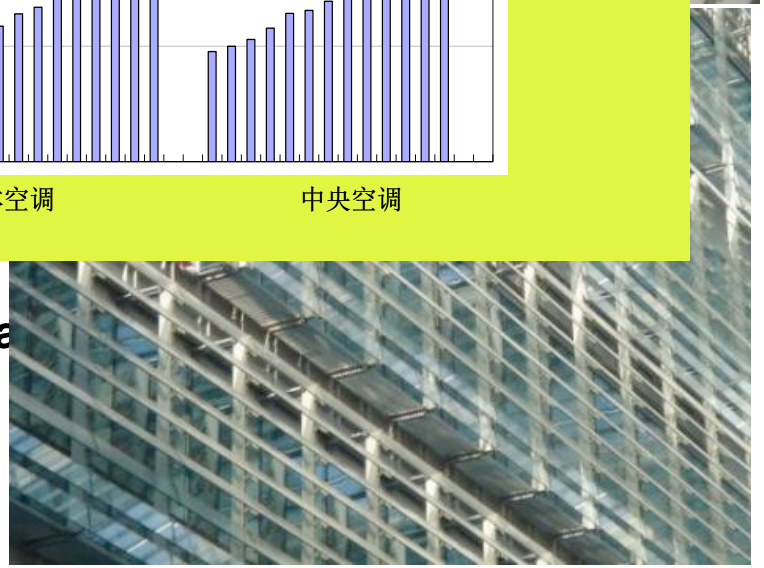




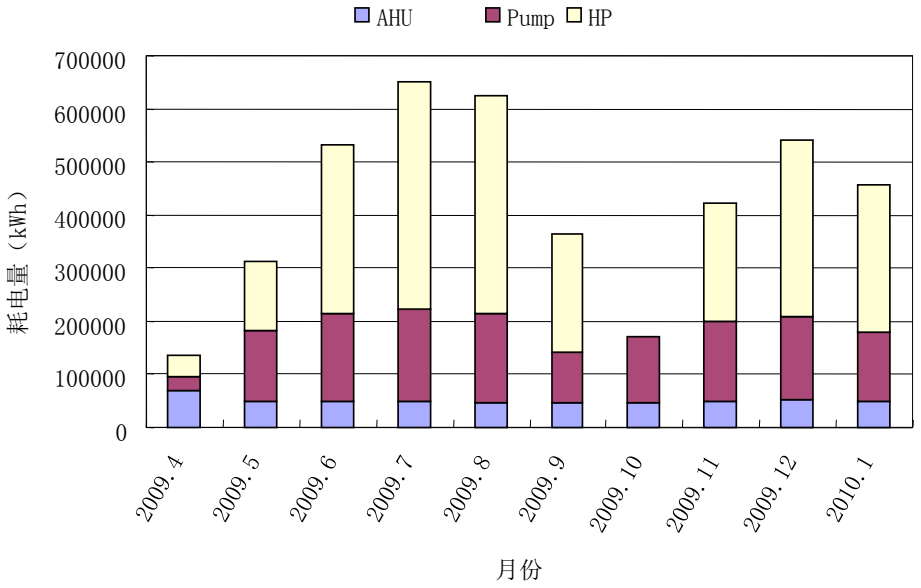


Key tech:

- BCCHP
- High performance windows
- Cool ceiling + displacement ventila
- Auto-lightings (dimming system)
- BAS
- 300m² PV
- Heat recover from exhust



XX Residential Block（Nanjing）



	Summer（May -Sept）	（April、Oct）	Winter（Nov—March）	Total
Per floor area kWh/m²	21.9	2.7	19.9	44.5
Per AC area kWh/m²	26.5	3.2	24.0	53.7

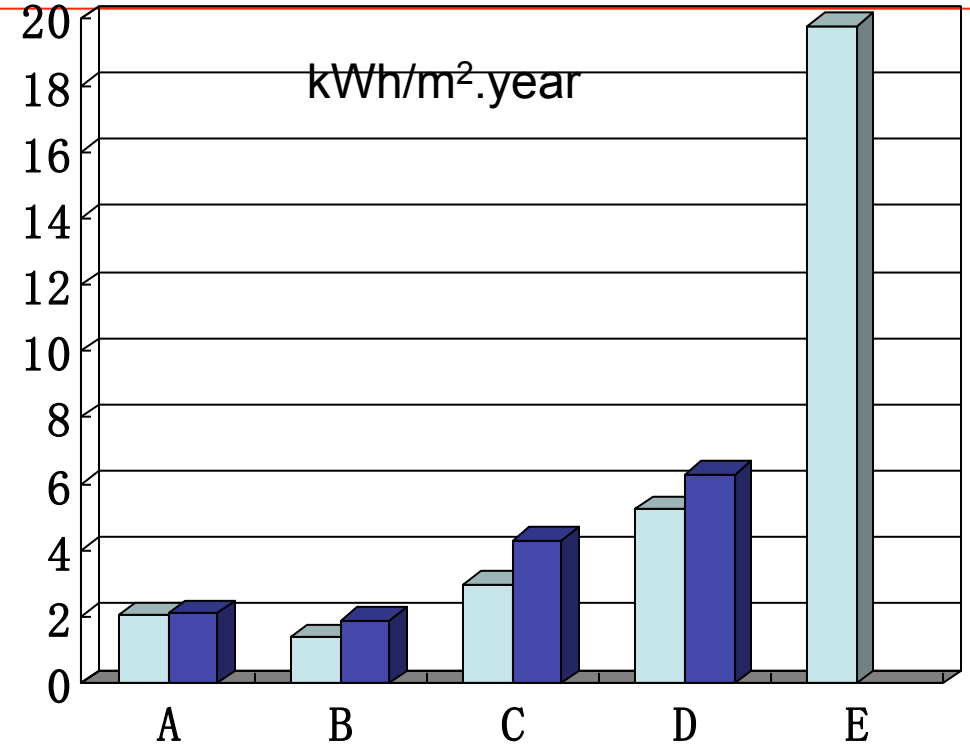
- **GTHP + cool ceiling + HR exhaust**
- **High insulation level on fabric**

- **Annual HVAC: 45 kWh/m².a**

Local residential electricity: 15~20 kWh/m².a

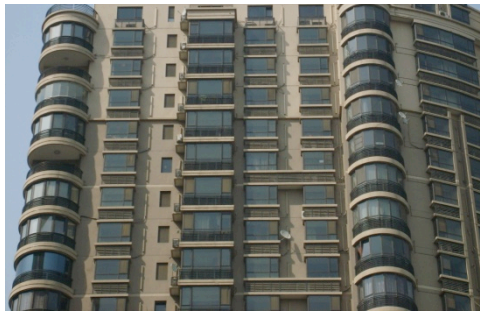
AC Energy for Residential in Beijing

AC energy during summer: kWh/m².a



A: split unit

B： split unit



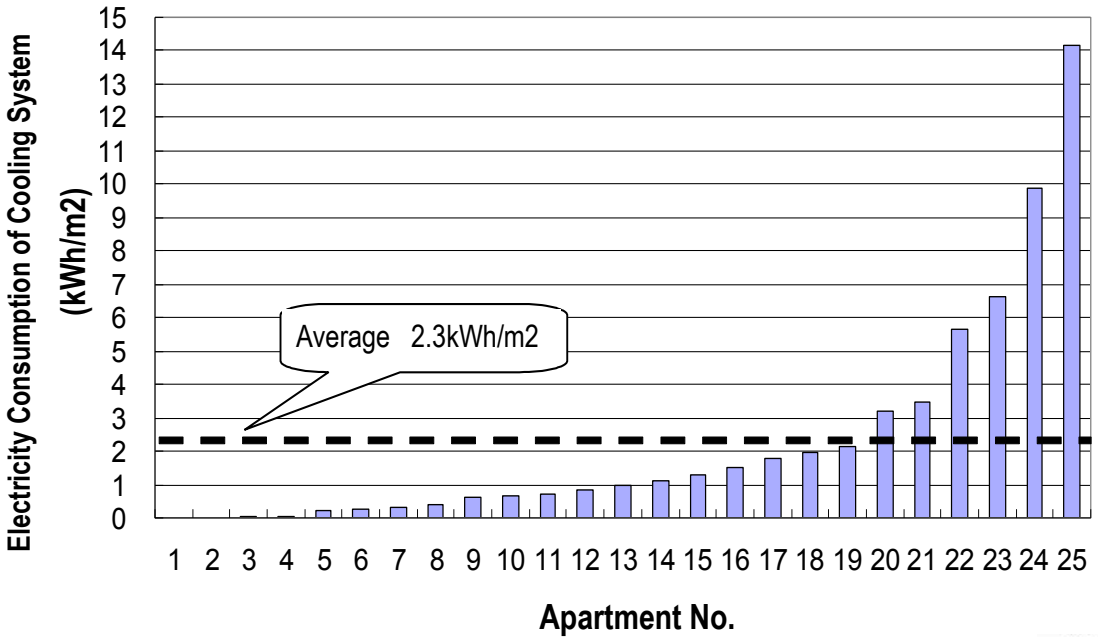
C： split unit

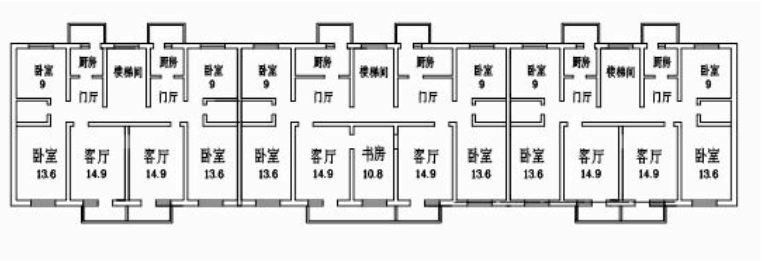
D：VRV

E: Centralized AC

Case Study: AC Energy for Building A

- **The measured energy consumption of AC in every unit of a residential building in Beijing, 2006, split unit**





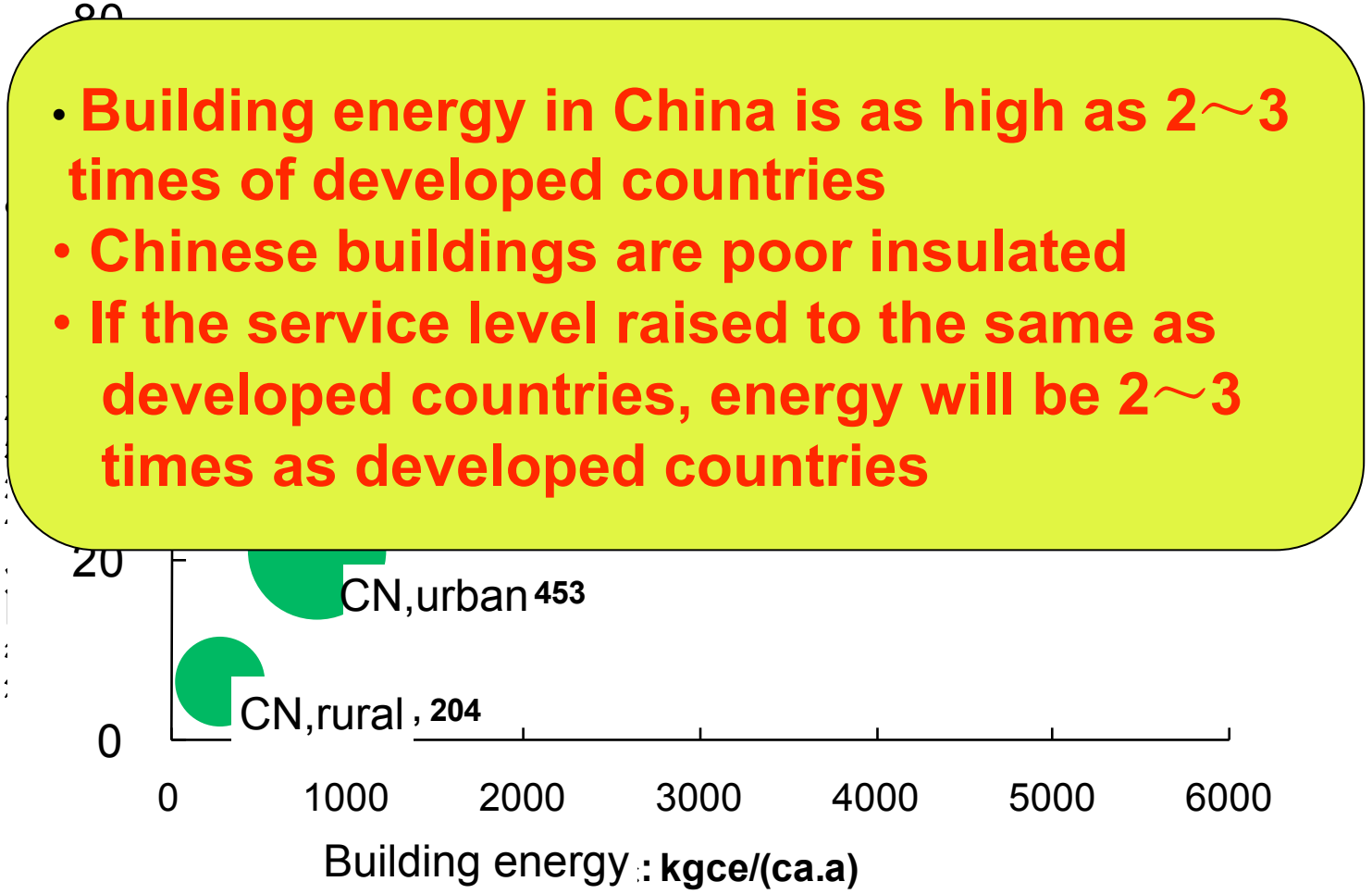
Where Differences Come From?

- Use modes：
  - Part time, part space vs full time, full space
- Service level
  - Outdoor air: supplied by fans vs open windows
  - Constant temp. & humid vs variation adapted
- Occupant adjustability
  - Fully auto, fully closed windows
  - Occupant adjusts
    - On/off device，open/close windows，curtain , set point

Do these low energy demo buildings really save energy?

- They are energy efficient：
  - Compared with design standard，save 65％
  - Compared with buildings in US，save 70％
  - Although use more energy than other buildings，the indoor climate improved greatly. If converting the service into same level, they would save energy
- Do not save energy at all:
  - The only criteria is real energy use data. If use more than other, it cannot be energy saving
  - Energy use = f(efficiency, use mode)

Current Situation of Building Energy



- **Building energy in China is as high as 2～3 times of developed countries**
- **Chinese buildings are poor insulated**
- **If the service level raised to the same as developed countries, energy will be 2～3 times as developed countries**

Fundamental Questions

- What does building energy saving mean? What is the criteria reference value?
- Could “50%、65% savings” be the target of China building energy?
- Will lifestyle in developing countries go to the same mode as the developed?
- What types of building should be built in these countries for the future?

The Reference Value

- **Shanghai residential building code：**
  - **In the code: electricity for HVAC < 55.1 kWh/m^2**
  - **Real case more than 70％ homes are less than 15 kWh/ m^2，including lighting and appliances**
  - **A zero energy residential communities in England，electricity use 3280 kWh/h.a，it is around 32.8 kWh/m^2.a，40% lower than Shanghai residential?**

- **What should be the reference mode/value for design/ evaluate/study building energy efficiency?**

Reference Value/Mode

- **“It is just a reference case. It can be used for comparison so to judge relative building energy performance”**
- **Question：If a building uses less energy than another at the reference case, is it always lower than the other at all cases?**

Different use modes need different techniques

- **Case A：external insulation at Guangzhou**
- **Full time 24℃ mode**
  - **Insulation is very useful to reduce heating & cooling demands**
- **Part time，18～28℃**
  - **Internal insulation is better than external**
  - **Over insulation may extend running hours of cooling**

Different use modes need different technologies

- **Case B：air tightness**

- **Full time，24℃**
  - **Air tightness is very important to reduce infiltration and save energy**

- **Part time，18～28℃**
  - **Natural ventilation can meet indoor climate for more than 50% during whole year. If air tightness against natural ventilation, ventilation should be put first**

Different use modes need different technologies

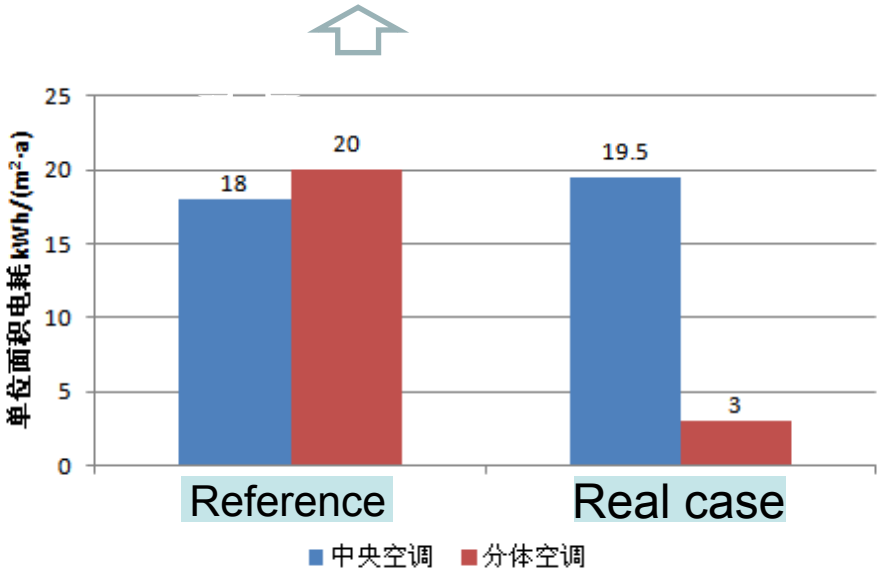
- Case C：outdoor air approach

- Fully automatic
  - Well air tightness，outdoor air ventilator，full time operation
  - Fan energy：~40 kWh/m^{2}a！

- Occupant control，open window
  - No need for fans，zero energy for fan, low energy for heating & cooling of outdoor air

Different use modes need different technologies

- **Case D: AC for residential buildings in Beijing**



	Use mode	Suitable AC
Reference	Full time , full space,18～24℃，windows closed，ventilation by fans	Centralized
Real mode	Most of residential AC operates at part time part space mode	Split unit

Centralized AC

Decentralized AC

Different use modes need different technologies

- Case E：AC for office

- Full time, constant temp. & humid
  - All air system, VAV with reheat at each terminal
  - Anything goes wrong, the service level can be maintained but energy will go up

- 8~ 10 hours a day, working days only
  - FCU，VRF appears better energy performance than all air system
  - Anything goes wrong, the service level will full down, but energy would also go down

Different use modes need different technologies

- Case F：district cooling
- 24 X 7 operation
  - Stable load，high efficiency
- Part time、part buildings demand
  - Load varies in a large range，difficulty in operation of distribution & source systems，low efficiency and high energy use

Different use modes need different technologies

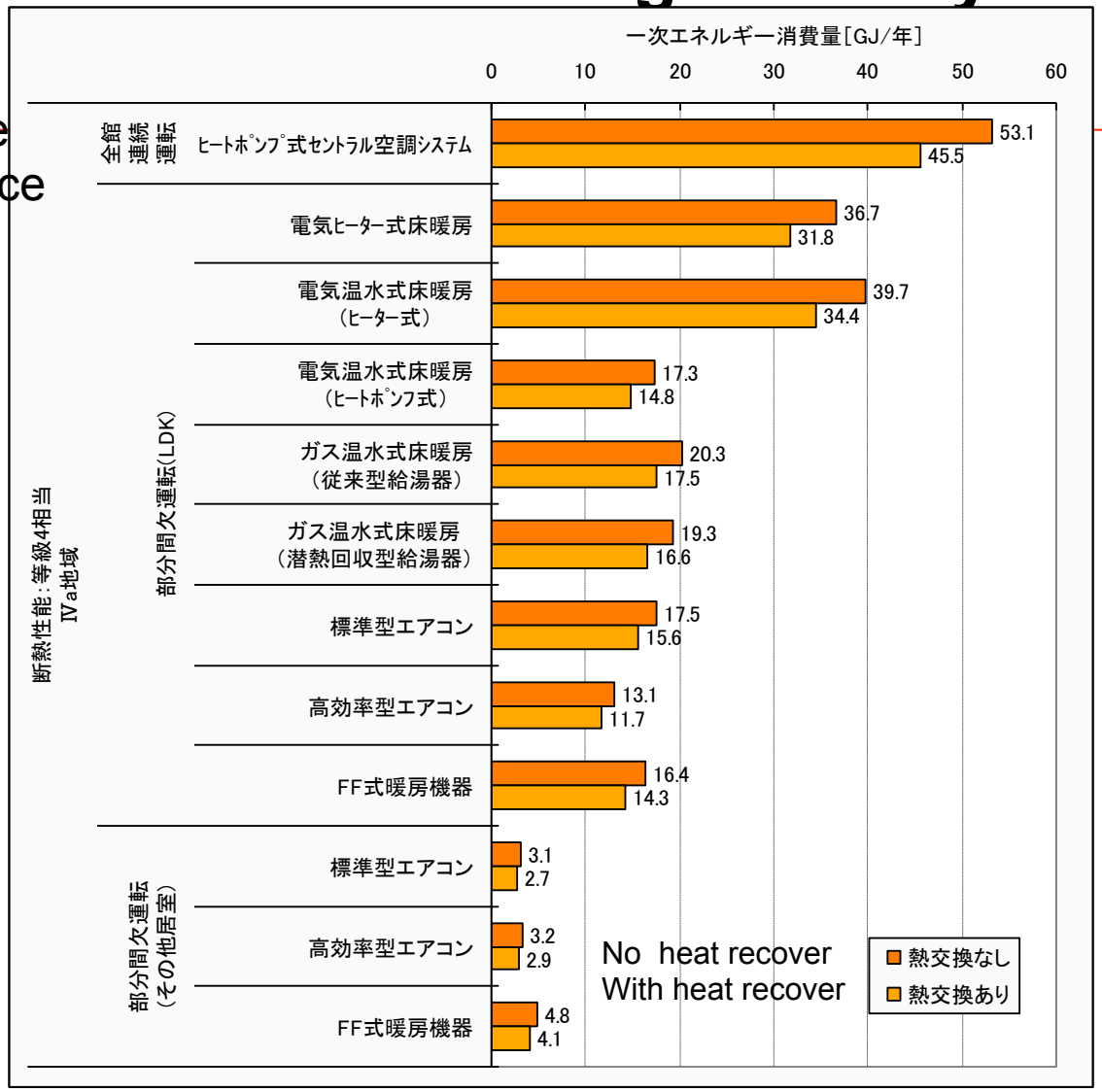
- Case G: domestic hot water system
- 600~1000 l/h.d (as in Japan, USA etc.):
  - If the heat source is high efficient, the centralized system can have great savings
- ~ 100 l/h.d (as in current China)
  - Pumps & heat loss of pipe become the major energy consumer, centralized shows much higher energy use than decentralized
  - Many new residential zones have to give out the centralized system and turn to decentralized

The difference in energy use due to different use modes is much larger than due to different technologies used

Whether a technology can save energy is highly dependent on the real use mode

Different use modes do need different technologies to save energy

Japan investigation result in residential buildings in Tokyo



Full time
Full space

Part time

Part space
Part time

Heat pump centralized

Electrical floor heater

Electrical hot water floor

Heat pump heater

Gas boiler heater

Gas condenser boiler

Standard heat pump

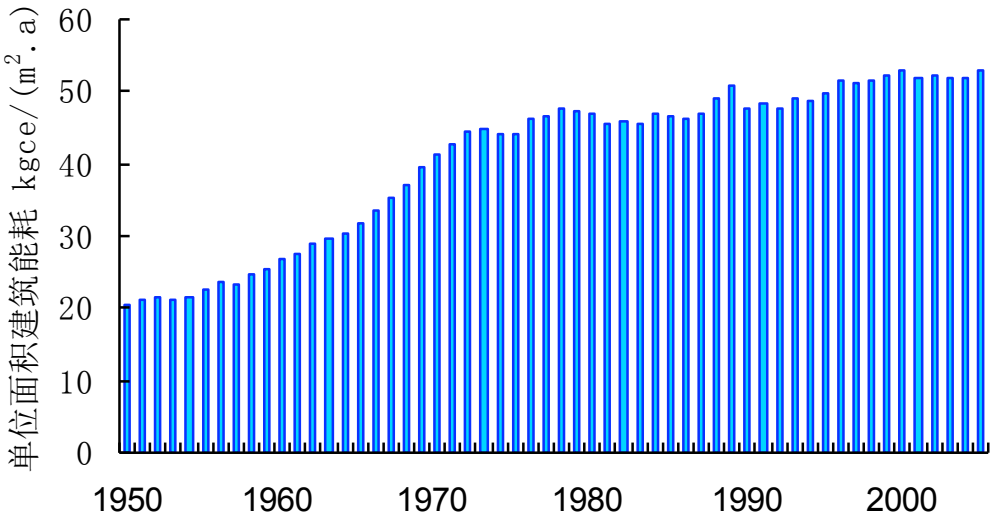
High efficiency heat pump

Standard heat pump

High efficiency heat pump

图表来源： ***Hisashi MIURA, National Institute for Land and Infrastructure Management,*** **Evaluation of Annual Energy Consumption in Residential House for Japanese Energy Efficiency Standard**

What should be the future building energy solution?

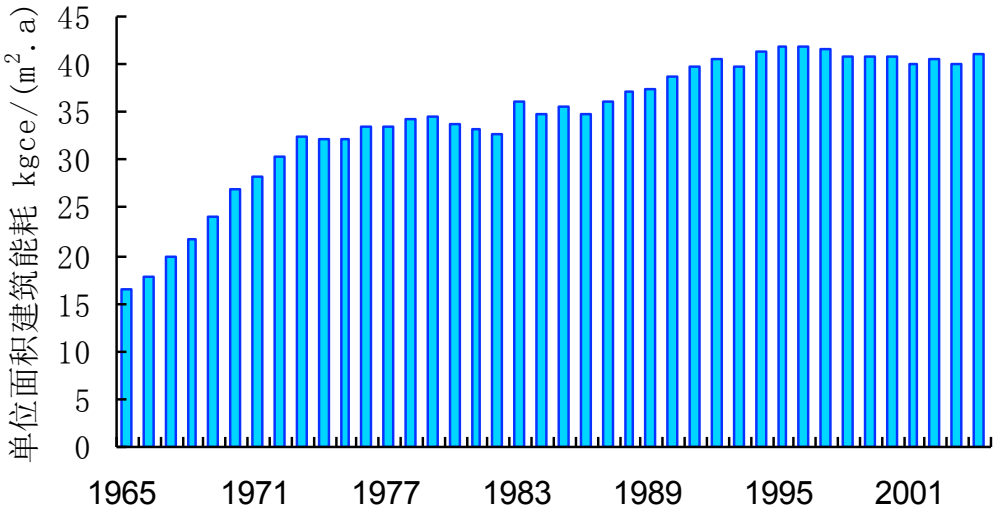


Building energy history in USA

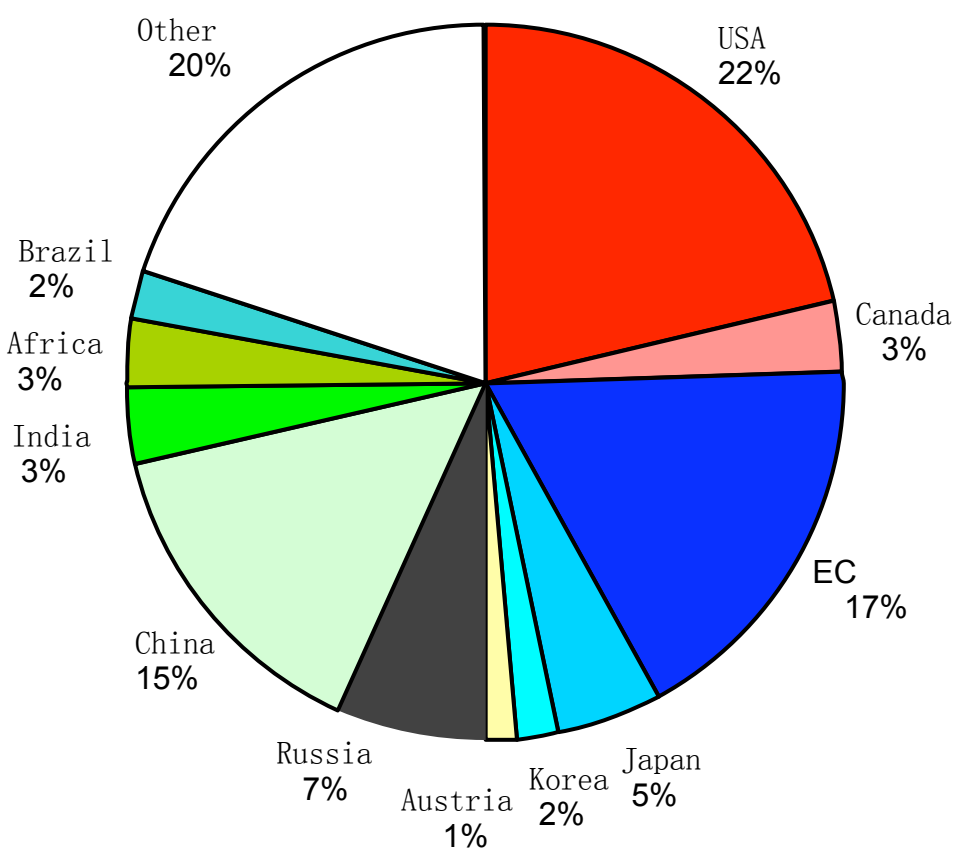
What happened in USA:

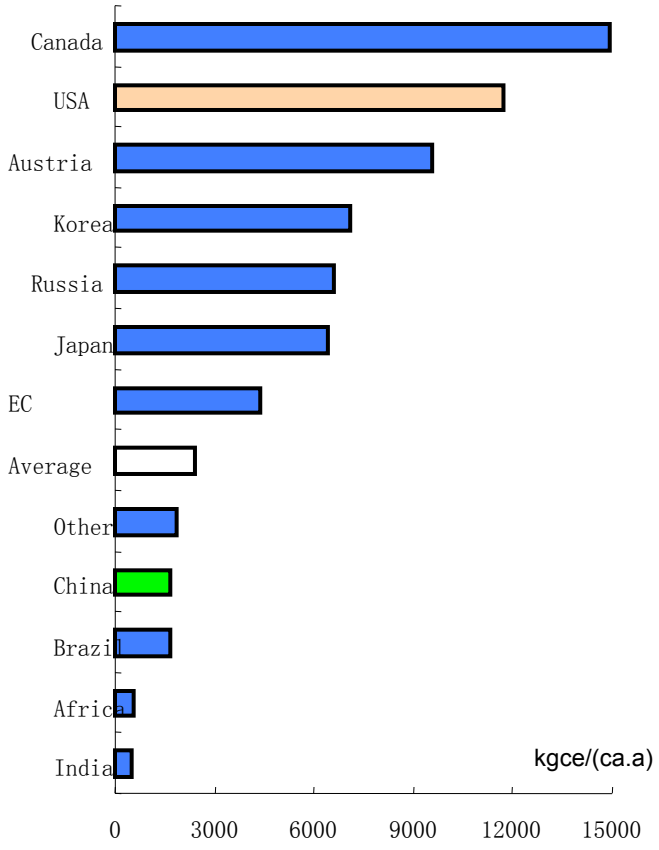
- Residential: went suburb, single house
- Non-residential: fully AC, fully close window, full time & full space

Building energy in Japan



Energy consumption in the world (2005)



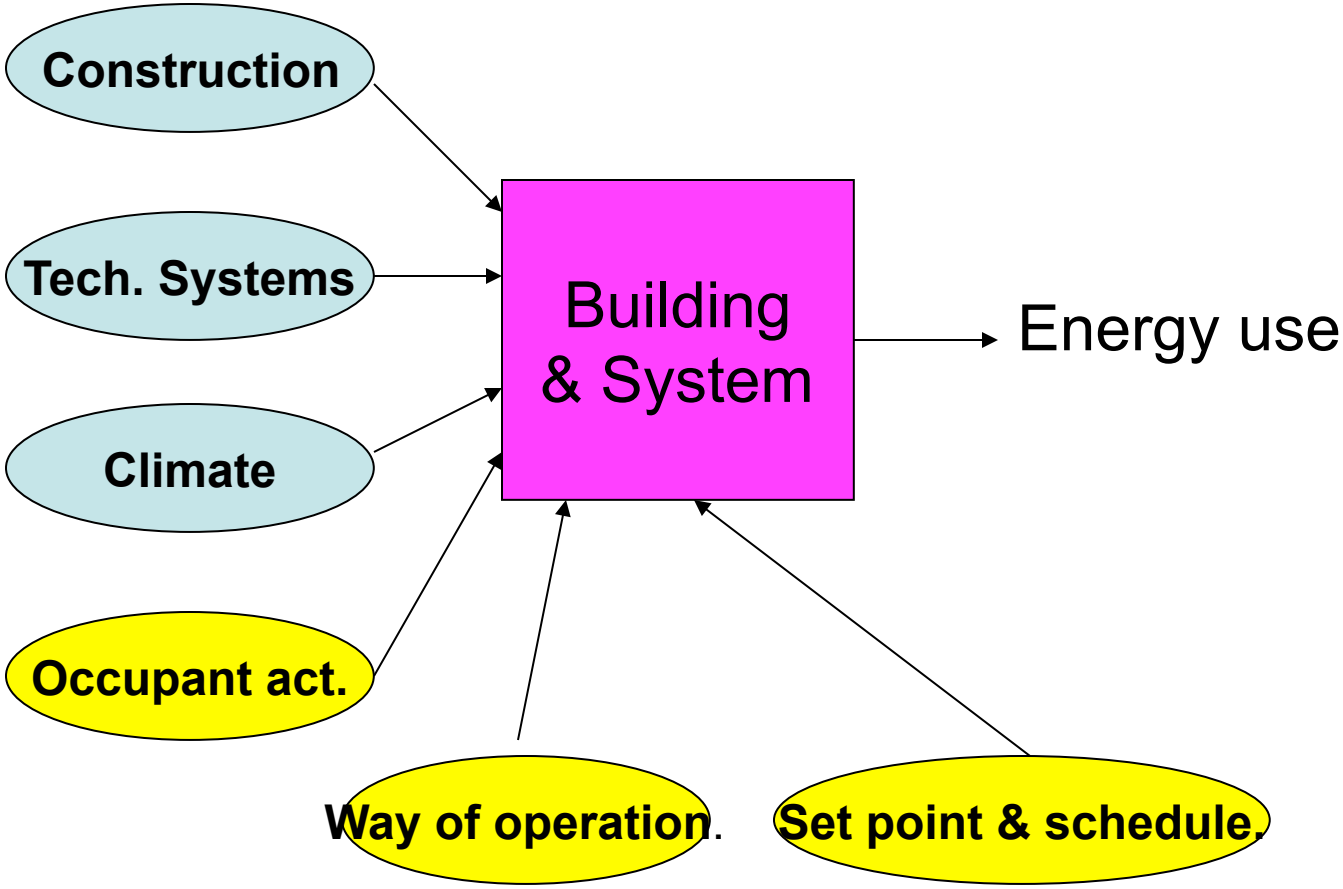


Data source: Energy Information Administration. International Energy Outlook 2008.

World building energy future

- If 7 billion population live in the same way as what USA 300 million does, we need 180% of current total world energy just to keep the buildings
- If all population live in the same way as OECD, we need 120% of current total world energy
- If all reach the same level as China urban (600 million), we need 40% of current total world energy, this may be the future level of the target for building energy saving

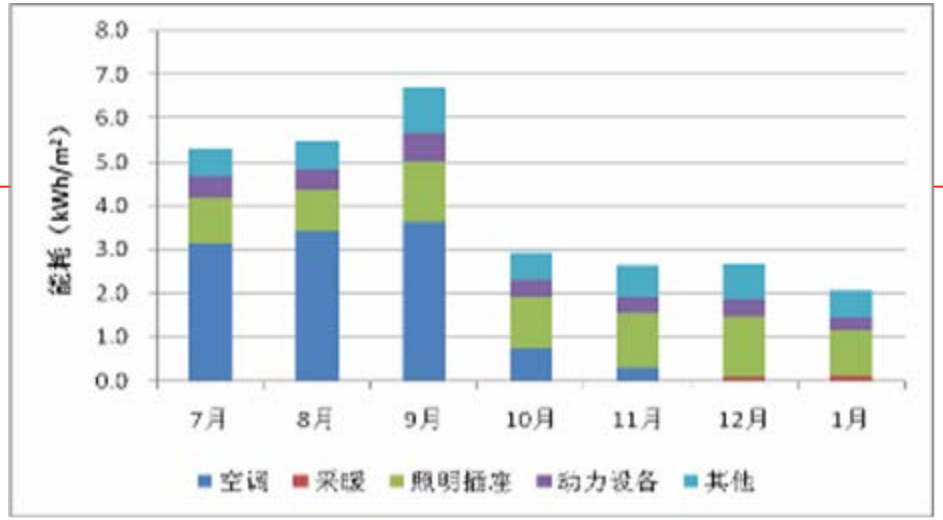
Factors influence building energy use

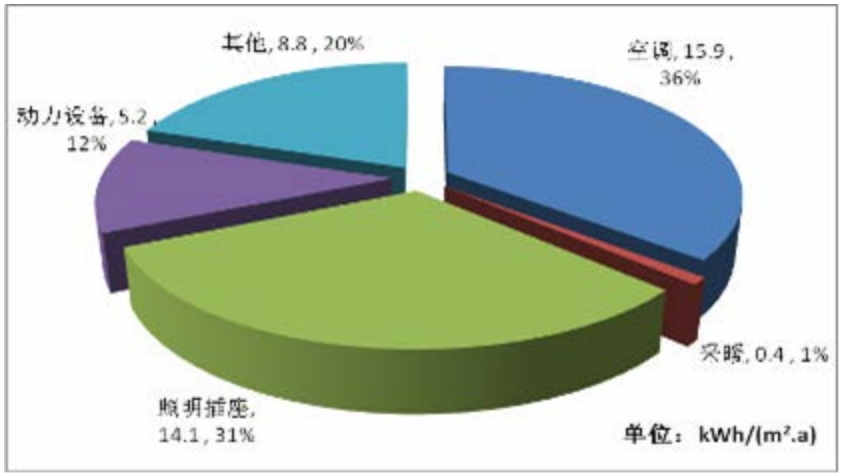


Two approaches to low energy buildings

- **Zero energy buildings based on renewable energy with a number of high techs**
  - **With current usage mode & service level**
  - **Save energy without change lifestyle**
  - **Maybe works for OECD**
- **Change to/keep the thrift lifestyle & use mode, improve indoor climate with suitable techs**
  - **Easy to reach with acceptable indoor environment**
  - **More practical for developing countries**

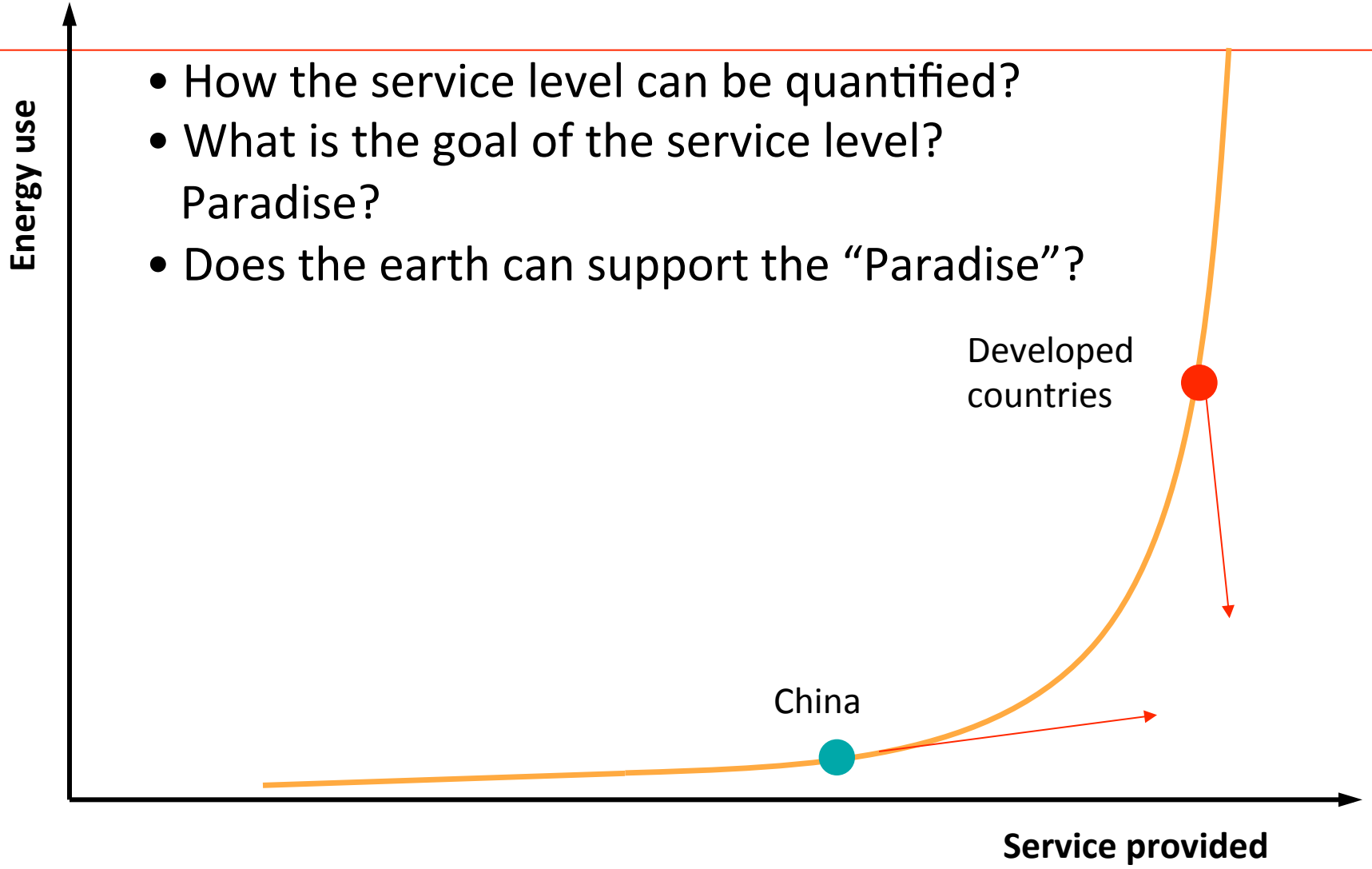
Shenzhen Jianke office building


8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
能耗（kWh/m²）
7月
8月
9月
10月
11月
12月
1月
空调
采暖
照明插座
动力设备
其他

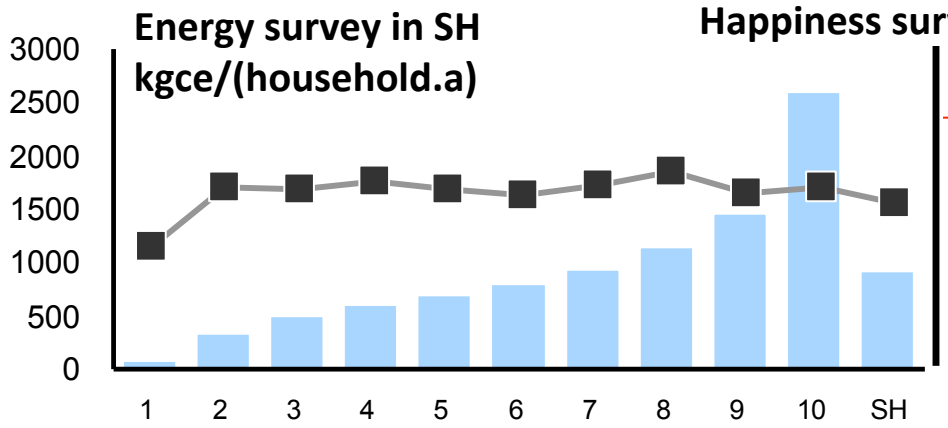

其他, 8.8, 20%
空调, 15.9, 36%
动力设备, 5.2, 12%
采暖, 0.4, 1%
照明插座, 14.1, 31%
单位：kWh/(m².a)

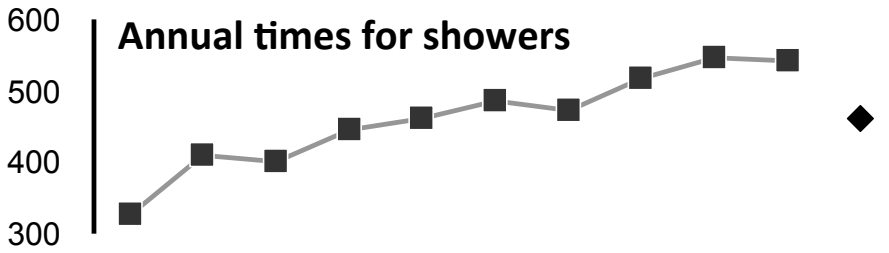
Energy use and service level

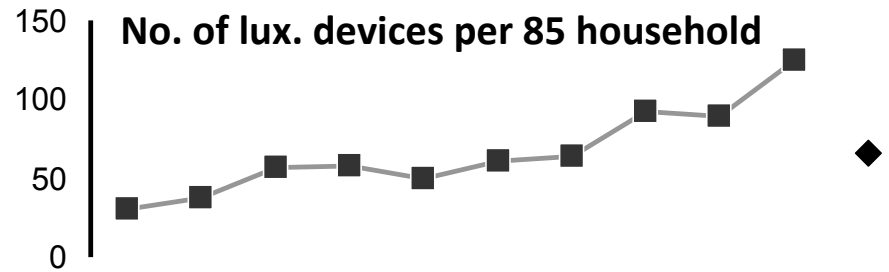
- How the service level can be quantified?
- What is the goal of the service level? Paradise?
- Does the earth can support the “Paradise”?

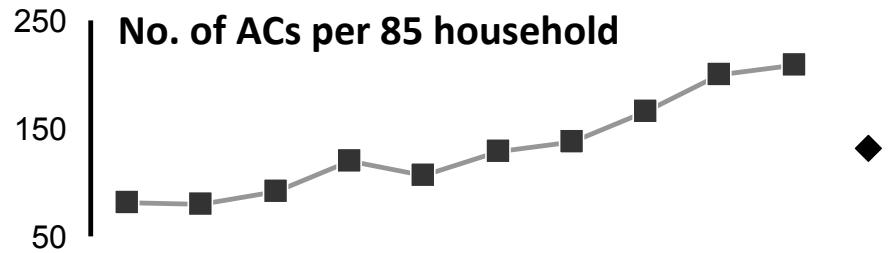


- How: more luxury behaviors → more energy ≠ happier









Changing to mechanical way of life
- Bathe 2 times per day
- Auto-service: elec. dryer…
- More control on temperature
- Etc…

Energy rises dramatically.
Happiness does not rise accordingly.

Green lifestyle
- Less energy use
- Happier

Reference mode

- For design, evaluation, labeling building & tech system
- Very different results will be obtained with different usage modes
  - Under “standard mode”: full time, full space
    - heavy, air-tight insulation with centralized system
    - Not taking opening window into account
  - Under “part time, part space” mode:
    - Natural vent., operable windows, fair insulation
    - Decentralized heating, cooling & hot water

Reference mode

- **We need different reference modes for design, evaluation & labeling buildings & systems**
- **Single standard reference mode may misguide**
- **Prof. Olesen Bjarne proposes a new ISO standard: building energy simulation input: 4 or 5 classes of usage modes**

Conclusion

- **Different use modes/demand need different technologies for energy saving**
- **Different use modes cause larger difference in energy usage than that caused by different technologies**
- **What mode should be for China's future buildings?**

China has to find a different approach for building energy

- Call for “green” lifestyle mode
- Design and build buildings according to thrift usage mode
- Design and evaluation criteria should be based on the thrift mode rather than on so called “standard mode”
- All the design guides, building code, text books should start from this point

Thank you